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ATLAS-ITk strip sensor quality control procedures and testing site qualification

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The high luminosity upgrade of the Large Hadron Collider, scheduled to become operational in 2029, requires the replacement of the ATLAS Inner Detector with a new all-silicon Inner Tracker (ITk). Radiation hard n+-in-p micro-strip silicon sensors were developed by the ATLAS ITk strip collaboration and are produced by Hamamatsu Photonics K.K. Production of the total amount of 22 000 ITk strip sensors has started in 2020 and will continue until 2025. The ATLAS ITk strip sensor collaboration has the responsibility to monitor the quality of the fabricated devices by performing detailed measurements of individual sensor characteristics and by comparing the obtained results with the on-site tests done by the manufacturer. Dedicated Quality Control (QC) procedures were developed to check whether the delivered large-format sensors adhere to the ATLAS specifications.

Although most of the ATLAS institutes have extensive experience with sensor studies and measurements, the institutes performing the QC testing of the pre-production and production ATLAS ITk strip sensors (QC sites) had to initially be qualified for multiple high-throughput tests by successfully completing a two-step Site Qualification Process. In the first step, the QC sites had to show that the necessary infrastructure for all required test operations was in place. In the second step, the capability of properly performing all QC test procedures on prototype sensors had to be demonstrated. To cross-check the results obtained by individual QC sites, reference samples with identified defects were exchanged among the participating sites and their results were compared. Excellent agreement was achieved among the participating QC sites that matched well the data provided by the manufacturer. Finally, the QC sites had to demonstrate safe handling procedures of the delivered sensors as well as the ability to correctly process the data, including uploading into the ITk Production Database.

The qualification process lasted less than a year, in spite of COVID slow-down. All seven QC sites went successfully through this process and were fully qualified in June 2021. Moreover, most of the QC tests achieved sensor testing throughputs that were already at the level required during the sensor production deliveries, which started in August 2021.

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